

CLAIMS

What is claimed is:

1. An annular recuperator for transferring heat from a hot fluid stream to a cool fluid stream, comprising:

a generally cylindrical annular housing defined by an inner diameter and an outer diameter, the housing having axially opposed first and second ends;

a plurality of cold cells extending generally radially from the inner diameter to the outer diameter in spaced-apart relationship to one another for conducting the cool fluid stream from a fluid inlet formed in the inner diameter near the second end to a fluid outlet formed in the outer diameter near the first end; and

a plurality of hot cells disposed within the housing in alternating relationship with the cold cells for conducting the hot fluid stream from the first end to the second end.

2. The annular recuperator of claim 1, wherein the plurality of cold cells including a fluid inlet and fluid outlet comprises:

a plurality of cold cells, each cold cell including a fluid inlet and a generally diagonally opposite fluid outlet to substantially equalize fluid flow through the cell.

3. The annular recuperator of claim 2, wherein each cold cell comprises:

a fluid inlet; and

a fluid outlet formed generally diagonally opposite to the fluid inlet to substantially equalize fluid flow paths through the cell.

4. The annular recuperator of claim 1, wherein each hot cell comprises:

an open passage defined by the two adjacent cold cells therebetween.

5. The annular recuperator of claims 2 or 4, wherein each cold cell further comprises:

a pair of substantially parallel, spaced-apart surfaces;
and

a plurality of flow partitions extending between the surfaces to define flow channels for conducting the cool fluid stream in a generally axial direction from the fluid inlet toward the fluid outlet.

6. The annular recuperator of claim 5, wherein each cold cell further comprises:

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directional channels extending from the fluid inlet and the fluid outlet toward the flow channels to conduct the cool fluid stream from the fluid inlet and to the fluid outlet, respectively.

7. The annular recuperator of claim 6, wherein the directional channels comprise:

directional channels extending from the fluid inlet and the fluid outlet toward the flow channels to substantially equalize fluid flow paths through the respective cold cell.

8. The annular recuperator of claim 1, wherein each cold cell comprises:

a first stage extending radially from the inner diameter to the outer diameter, the first stage including a fluid inlet formed in the inner diameter near the second end and an intermediate fluid outlet formed in the outer diameter; and

a second stage extending radially from the inner diameter to the outer diameter and coplanar with the first stage, the second stage including an intermediate fluid inlet formed in the outer diameter and in communication with the intermediate fluid outlet, and further including a fluid outlet formed in the inner diameter near the first end.

9. The annular recuperator of claim 1, wherein each cold cell comprises:

a plurality of coplanar, axially aligned stages extending radially from the inner diameter to the outer diameter, each stage including a fluid inlet and a generally diagonally opposed fluid outlet, each stage having at least one of the inlet or the outlet in fluid communication with the outlet or the inlet, respectively, of an adjacent stage.

10. The annular recuperator of claims 8 or 9, wherein the stage at the first end is formed from a different material than the other stages.

11. The annular recuperator of claim 8, wherein the second stage is formed from a high-temperature alloy and the first stage is formed from a stainless steel.

12. A method for transferring heat from a hot fluid stream to a counter-flowing cool fluid stream, comprising:

providing a generally cylindrical annular housing defined by an inner diameter and an outer diameter, the housing having axially opposed first and second ends;

providing a plurality of cold cells extending radially from the inner diameter to the outer diameter in spaced-apart

relationship to one another, each cold cell including a fluid inlet formed in the inner diameter near the second end and a fluid outlet formed in the outer diameter near the first end;

providing a plurality of hot cells disposed within the housing in alternating relationship with the cold cells;

passing the hot fluid stream through the hot cells from the first end of the housing to the second end; and

passing the cool fluid stream through the cold cells from the fluid inlets to the fluid outlets to acquire heat energy from the hot fluid stream.

13. The method of claim 12, wherein providing the plurality of cold cells comprises:

providing a fluid inlet and a generally diagonally opposite fluid outlet in each cold cell to substantially equalize fluid flow through the cell.

14. The method of claim 13, wherein providing an inlet and an outlet comprises:

providing a fluid inlet and a generally diagonally opposite fluid outlet to substantially equalize fluid flow paths through the cell.

15. The method of claim 12, wherein each hot cell comprises:

an open passage defined by the two adjacent cold cells therebetween.

16. The method of claims 13 or 15, wherein each cold cell further comprises:

a pair of substantially parallel, spaced-apart surfaces; and

a plurality of flow partitions extending between the surfaces to define flow channels for conducting the cool fluid stream in a generally axial direction from the fluid inlet toward the fluid outlet.

17. The method of claim 16, wherein each cold cell further comprises:

directional channels extending from the fluid inlet and the fluid outlet toward the flow channels to conduct the cool fluid stream from the fluid inlet and to the fluid outlet, respectively.

18. The method of claim 17, wherein each cold cell comprises:

directional channels extending from the fluid inlet and the fluid outlet toward the flow channels to substantially equalize fluid flow paths through the respective cold cell.

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19. The method of claim 12, wherein each cold cell comprises:

a first stage extending radially from the inner diameter to the outer diameter, the first stage including a fluid inlet formed in the inner diameter near the second end and an intermediate fluid outlet formed in the outer diameter; and

a second stage extending radially from the inner diameter to the outer diameter and coplanar with the first stage, the second stage including an intermediate fluid inlet formed in the outer diameter and in communication with the intermediate fluid outlet, and further including a fluid outlet formed in the inner diameter near the first end.

20. The method of claim 12, wherein each cold cell comprises:

a plurality of coplanar, axially aligned stages extending radially from the inner diameter to the outer diameter, each stage including a fluid inlet and a generally diagonally opposed fluid outlet, each stage having at least one of the inlet or the outlet in fluid communication with the outlet or the inlet, respectively, of an adjacent stage.

21. The method of claims 19 or 20, wherein the stage at the first end is formed from a different material than the other stages.

22. The method of claim 19, wherein the second stage is formed from a high-temperature alloy and the first stage is formed from a stainless steel.

23. A method of transferring heat from a hot fluid stream to a cold fluid stream, comprising:

providing a plurality of cold cells, each cold cell for conducting cold fluid from a respective cold cell inlet to a respective cold cell outlet over a plurality of fluid flow paths having substantially equal path lengths;

providing a plurality of hot cells, each hot cell for conducting hot fluid from a respective hot cell inlet to a respective hot cell outlet over a plurality of fluid flow paths having substantially equal path lengths;

disposing the cold cells and hot cells in adjoining, alternating relationship to form an annular, generally cylindrical pattern of alternating hot and cold cells;

passing the hot fluid through the hot cells from the hot cell inlets to the hot cell outlets; and

passing the cold fluid through the cold cells from the cold cell inlets to the cold cell outlets to receive heat energy from the hot fluid.

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24. The method of claim 23, wherein providing a plurality of cold cells comprises:

providing a plurality of cold cells, each for conducting cold fluid over a plurality of fluid flow paths having substantially equal fluid flow resistance.

25. The method of claims 23 or 24, wherein each cell comprises:

the cold cell inlet formed at an inner diameter of the annular pattern near a first axial end; and

the cold cell outlet spaced generally diagonally opposite from the cold cell inlet and formed at an outer diameter of the annular pattern near a second axial end opposite from the first axial end to substantially equalize fluid flow through the cell.

26. The method of claim 24, wherein each hot cell comprises:

an open passage defined by the two adjacent cold cells therebetween.

27. The method of claims 23 or 26, wherein each cold cell further comprises:

a pair of substantially parallel, spaced-apart surfaces; and

a plurality of flow partitions extending between the surfaces to define flow channels for conducting the cool fluid

stream in a generally axial direction from the fluid inlet toward the fluid outlet.

28. The method of claim 27, wherein each cold cell further comprises:

directional channels extending from the fluid inlet and the fluid outlet toward the flow channels to conduct the cool fluid stream from the fluid inlet and to the fluid outlet, respectively.

29. The method of claim 28, wherein each cold cell comprises:

directional channels extending from the fluid inlet and the fluid outlet toward the flow channels to substantially equalize fluid flow paths through the respective cold cell.

30. The method of claims 23 or 24, wherein each cold cell comprises:

a first stage extending radially from the inner diameter to the outer diameter, the first stage including a fluid inlet formed in the inner diameter near the second end and an intermediate fluid outlet formed in the outer diameter; and

a second stage extending radially from the inner diameter to the outer diameter and coplanar with the first stage, the second stage including an intermediate fluid inlet formed in the

outer diameter and in communication with the intermediate fluid outlet, and further including a fluid outlet formed in the inner diameter near the first end.

31. The method of claim 30, wherein the second stage is formed from a high-temperature alloy and the first stage is formed from a stainless steel.

32. The method of claims 23 or 24, wherein each cold cell comprises:

a plurality of coplanar, axially aligned stages extending radially from the inner diameter to the outer diameter, each stage including a fluid inlet and a generally diagonally opposed fluid outlet, each stage having at least one of the inlet or the outlet in fluid communication with the outlet or the inlet, respectively, of an adjacent stage.

33. The method of claim 32, wherein the stage at the first end is formed from a different material than the other stages.

34. A system, comprising:

a combustor for combusting compressed air and fuel to generate hot gas;

a turbine driven by the hot gas and having an outlet for the hot gas;

a compressor with an outlet, the compressor rotationally coupled to the turbine to compress air for the combustor; and

an annular recuperator for transferring heat from the hot gas to the compressed air, the recuperator comprising:

a generally cylindrical annular housing defined by an inner diameter substantially overlying the turbine and the compressor, an outer diameter, and axially opposed first and second ends, the first end in communication with the turbine hot gas outlet;

a plurality of cold cells extending radially from the inner diameter to the outer diameter in spaced-apart relationship to one another for conducting the compressed air from a fluid inlet formed in the inner diameter near the second end and in communication with the compressor outlet to a fluid outlet formed in the outer diameter near the first end and in communication with the combustor; and

a plurality of hot cells disposed within the housing in alternating relationship with the cold cells for conducting the hot gas from the first end to the second end.

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35. The system of claim 34, wherein the plurality of cold cells including a fluid inlet and fluid outlet comprises:

a plurality of cold cells, each cold cell including a fluid inlet in communication with the compressor outlet and a generally diagonally opposite fluid outlet in communication with the combustor to substantially equalize fluid flow through the cell.

36. The system of claim 35, wherein each cold cell comprises:

a fluid inlet and a generally diagonally opposite fluid outlet to substantially equalize fluid flow paths through the cell.

37. The system of claim 34, wherein each hot cell comprises:

an open passage defined by the two adjacent cold cells therebetween.

38. The system of claims 35 or 37, wherein each cold cell further comprises:

a pair of substantially parallel, spaced-apart surfaces;
and

a plurality of flow partitions extending between the surfaces to define flow channels for conducting the compressed

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air in a generally axial direction from the fluid inlet toward the fluid outlet.

39. The system of claim 38, wherein each cold cell further comprises:

directional channels extending from the fluid inlet and the fluid outlet toward the flow channels to conduct the compressed air from the fluid inlet and to the fluid outlet, respectively.

40. The system of claim 39, wherein the directional channels comprise:

directional channels extending from the fluid inlet and the fluid outlet toward the flow channels to substantially equalize fluid flow paths through the respective cold cell.

41. The system of claim 34, wherein each cold cell comprises:

a first stage extending radially from the inner diameter to the outer diameter, the first stage including a fluid inlet formed in the inner diameter near the second end and in communication with the compressor outlet, the first stage further including an intermediate fluid outlet formed in the outer diameter; and

a second stage extending radially from the inner diameter to the outer diameter and coplanar with the first stage, the

TOP SECRET

second stage including an intermediate fluid inlet formed in the outer diameter and in communication with the intermediate fluid outlet, and further including a fluid outlet formed in the inner diameter near the first end and in communication with the combustor.

42. The system of claim 34, wherein each cold cell comprises:

a plurality of coplanar, axially aligned stages extending radially from the inner diameter to the outer diameter, each stage including a fluid inlet and a generally diagonally opposed fluid outlet, each stage having at least one of the inlet or the outlet in fluid communication with the outlet or the inlet, respectively, of an adjacent stage.

43. The system of claims 41 or 42, wherein the stage at the first end is formed from a different material than the other stages.

44. The system of claim 41, wherein the second stage is formed from a high-temperature alloy and the first stage is formed from a stainless steel.